BELLCOMM, INC.
1100 Seventeenth Street, N.W. Washington, D.C. 20036

SUBJECT: Critical Design Review of the ATM S082A XUV Coronal Spectroheliograph and the S082B XUV Spectrograph Experiments - Case 620

DATE: August 28, 1968

FROM: S. H. Levine
T. C. Tweedie, Jr.

MEMORANDUM FOR FILE

The authors participated in the Critical Design Review (CDR) of the NRL (Naval Research Laboratory) S082A XUV Coronal Spectroheliograph and the S082B XUV Spectrograph experiments held at Boulder, Colorado, on July 29 through August 2, 1968. The purpose of the CDR was to examine in detail the approaches, plans, designs and specifications prepared by the experiment contractor prior to initiation of the hardware manufacturing phase of instrument development.

Personnel from the Ball Brothers Research Corporation (the experiment development contractor) and NRL (the Principal Investigator) presented a detailed review of the experiment objectives, experiment operations and subsystem designs including interfaces with ATM systems. The review team consisted of representatives from MSFC, MSC and NASA Headquarters. Written comments by the review team were solicited by the MSFC co-chairmen, Mr. A. F. White, Jr., R-ASTR-DIR and Mr. W. C. Keathley, I-S/AA.

Comments and observations on the CDR generated by the authors are contained in Appendix A.

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APPENDIX A

MLS Comments and Observations on the NRL Critical Design Review

1. No integrated vibration or thermal testing on the NRL experiments has been performed to permit correlation of actual hardware capabilities with the existing analytical models. In view of the lack of test data to substantiate the soundness of the design approaches for both instruments, it is felt that the CDR was somewhat premature.

2. Structural and thermal analytical models presented by BBRC were incomplete. Recent changes to both instruments, in particular the addition of thermal control system stand-off heaters, should be incorporated.

3. Thermal Mechanical Units (TMU) of both instruments do not adequately represent the flight article configuration. Changes to the TMUs, particularly with the addition of stand-off heaters, should be made.

4. Flight-type optics are not being procured by NRL for the experiments on the prototype ATM, consequently the prototype NRL experiments are not flyable. Since this is not consistent with the established ATM program plans, MSFC should investigate this inconsistency.

5. Experiment optics alignment checkout in the Thermal Vacuum Chamber requires that an ultraviolet light source, acceptable to the Principal Investigator, be provided. MSFC should consider the incorporation of acceptable light sources in test planning to assure that optical path checkout is included in end-to-end verification of experiment systems.

6. The Fairchild LPDTμL 9040 and DTμL 9900 (formerly 930) series micrologic electronic flatpacks are currently used by several NASA programs including the LM and the ATM. Imperfections in the Fairchild metallization process has resulted in electrical discontinuities. NRL and MSFC reported that GSFC and Fairchild believe that a fabrication "fix" has been found. Dr. Tousey of NRL is concerned that due to the widespread application of this micrologic throughout NASA, a priority listing may be required in order to assure that experiment and ATM schedules can be maintained.

7. NRL electronic boxes have printed circuit boards which are hardwired to the external connectors of the boxes. Should a fault occur, internal to the box, it would necessitate removal of the entire box and return to the BBRC facility for rework. This design philosophy limits the inherent flexibility of printed circuit board application for maintainability and imposes a more costly spare program to support these instruments on ATM. In view of the advanced stage of electronics development of these instruments, redesign does not appear practical or justifiable. Sufficient spares should, therefore, be planned and should be made available at appropriate test locations such that minor electronic malfunctions do not result in lengthy program delays or hardware repair delays.

8. Locating ECE (Experiment Checkout Equipment) connectors on the front-end of both instruments prohibits consideration of using NRL carry-near equipment late in the countdown (lack of accessibility after approximately T minus 43 days). This infers that the ATM Control and Display Console in conjunction with ATM telemetry will be used to pinpoint malfunctions in the NRL instruments after closeout of the ATM experiment package. Unless an unreasonable amount of instrument measurements are provided, it may be difficult to determine the level of performance degradation that the instrument has experienced, with certain malfunctions, and thus determine whether it can be operated effectively with some degree of degradation. It is felt that without this knowledge on all the experiments, any submodule or subassembly malfunction may require costly disassembly of the entire spacecraft from the launch vehicle and return to the MSOB. Further study is required to determine whether these instruments and other ATM experiments are being designed to make the most out of operating in degraded modes and to take advantage of carry-near checkout capabilities as late in the countdown as possible.

9. Prior to launch, the ATM experiment package will be thermally conditioned to a temperature of 75 $\pm$ 5°F and launch will occur with experiments and the ATM deactivated. The existing MSFC/Martin-Marietta Corporation timeline analysis on AAP-4 has revealed that activation of the ATM thermal control system will occur in the neighborhood of 36 hours after the AAP-4 launch. It has been estimated by MSFC that the ATM canister, with experiments, will stabilize in orbit at a temperature of about 40°F prior to activation. Continued analysis is required to determine the time required to thermally stabilize the ATM canister following activation of the ATM thermal control system and also the time required to thermally stabilize each NRL experiment after experiment activation. The time required to achieve thermal stabilization during post launch activation may affect the scheduled timeline for solar observation by these experiments.

10. During EVA film camera retrieval, the experiment electrical power will be disabled for astronaut protection. The ATM Control and Display Console may be unattended and the experiment heaters may be disabled for a period of up to 9.5 hours.(1) In this time period the experiment will cool down. Thermal analysis is needed to determine the time required for thermal stabilization following each EVA (3 film replacement periods during the 56-day mission). The time required to achieve thermal stabilization following EVA may affect the scheduled timeline for NRL experiment solar observation.

11. Section 13 of the document, 50M02462 Revision A, ATM EIDD S-082A Extreme Ultraviolet Spectroheliograph and S-082B Extreme Ultraviolet Spectrograph identifies the following requirement:

> "The storage temperature required for the film is 40 plus or minus 5°F at a relative humidity of between 40 and 60 percent. The film will not be subjected to temperatures in excess of 80°F."

This requirement has been established to preclude degradation of the film emulsion which may occur as a result of long duration exposure at elevated temperature. Orbital storage of film is currently not in a controlled thermal environment and temperatures in excess of 80°F may occur in the CM and in the LM during certain phases of the AAP-3/4 mission.(2) AAP currently does not have the capability of satisfying the environmental requirements for NRL film canisters. NRL should reassess the need for these requirements in light of the potential impact to AAP.

12. To operate as designed, the stand-off heaters on S-082 currently require a vacuum between the instrument and the heater. This may impose some limitations on test planning and experiment checkout subsequent to ATM Thermal Vacuum Chamber testing.

13. To preclude further growth of the ATM Control and Display Console, the emergency aperture door "open" commands proposed by NRL/BBRC for the XUV monitor, the XUV spectrograph, and the XUV spectroheliograph should employ the ATM digital address system (DAS) keyboard for these functions, as was suggested by MSFC.

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(1) Critical Design Review of ATM Experiment S-054, X-Ray Spectrographic Telescope - Case 620, Memorandum for File, July 15, 1968, S. H. Levine and T. C. Tweedie, Jr.

(2) Trip Report - ATM Camera Handling Meeting - Case 620, Memorandum for File, August 21, 1968, S. H. Levine

14. Failure modes for several of the electromechanical devices carried on both NRL instruments should be reexamined. For example:

a. A solenoid-cam electromechanical grating changer system is currently employed on the S-082A Spectroheliograph to drive the grating $\pm 3°43'$ thereby shifting its position from a short wavelength to a long wavelength operating range. Two solenoids are used, one for clockwise drive, the other for counterclockwise drive. If either solenoid fails, the grating can be driven in only one direction and, hence, can only operate in one desired position. Failure of both solenoids leaves the grating in the instantaneous position at the time of failure. To overcome these potential failures it is desirable to add a spring mechanism such that, if solenoid failure occurred the spring would mechanically restore the grating to one of the desired positions for experiment operation. In addition, if a spring is added, it may be possible to eliminate one of the solenoids.

b. Failure of the short wavelength rejection mirror motor drive system on S-082A may leave this heat rejection mirror in an undesirable position. A spring recovery mechanism could be incorporated on this device to reposition the mirror to a preselected position for degraded instrument operation.

c. The predisperser gratings for the S-082B experiment are mounted 180° apart in the Predisperser Assembly. One grating provides short wavelength dispersion while the other provides long wavelength dispersion. Currently this instrument employs a solenoid to release the mirror for rotation and a stepper motor-gear train to drive the assembly to either the short or long wavelength position. Failure of the drive or motor system in some intermediate position of travel could render the entire instrument useless. It is suggested that provisions be made for a spring override such that failure to the drive system of this assembly would automatically restore the gratings to the most desirable wavelength range for instrument operation.

d. The NRL instrument aperture doors (one on the A instrument and two on the B instrument) should be designed to fail in an open position, to insure that door drive mechanism failure does not preclude data acquisition by the experiment.

15. The Frequency Coupled Isolator Assembly provides a controlled frequency source to the S-082B instrument stepper motors, optics drive assemblies, camera exposure time computer, flare mode control circuits and aperture door drive system. Failure of the HP4310 photon coupled isolation diode which is critical to this assembly would be catastrophic to the entire S-082B instrument. In view of the fact that there has been no previous space program experience with this device, serious consideration should be given to providing an alternate scheme for circuit isolation and/or for providing redundancy for this part of the system.

This diode is also used in the Photon Coupled Isolator Assembly which provides inputs for driving the timing data diode matrix used for recording data on experiment film. Considering the importance of this circuitry to the accurate correlation of film data with mission elapsed time, ATM positioning data, and exposure times, reevaluation of this circuit design, as well as the need for redundancy in this application also seems warranted.

16. It was revealed that electronics packages on the S-082B instrument do not have vent holes to provide a path for venting the units and the outgassed products to vacuum. All modules should provide this capability in accordance with the suggestion by Mr. Purcell of NRL. It is further suggested that an examination of other ATM systems and experiments be performed to insure that this venting capability is incorporated throughout the ATM.

17. The current design of S-082B does not incorporate means for illuminating the reflecting slit plate of the spectrometer for checkout of the T.V. white light display for the S-082B spectrograph. This means that after closure of the experiment aperture door, there is no way to provide an open loop checkout of the system (i.e., optical path, image dissector tube, and TV camera). It should be determined if this is acceptable to MSFC and to the PI.

18. The camera shutter plate (p. 66 of the CDR handout) will not seal the instrument from external moisture or gases. Presently this plate will only protect the instrument from gross particulate contamination. During EVA for NRL camera retrieval metabolic gases and water vapor are emitted from the space suit. Possible contamination of the experiment by these sources should be examined.

19. In recent months, NRL A and B instruments have increased a total of about 55 pounds above the control weight. Efforts to reduce the growth rate of experiment weights should be undertaken by MSFC.

The total ATM experiment package currently weighs more than the maximum design load limit (control weight) for the

gimbal system. A costly gimbal system redesign may be necessary if this weight trend of the ATM experiment package subsystem continues.

20. The NRL S-082B spectrograph design currently can accommodate a torque motor in the primary mirror housing which would permit this instrument to track the solar limb in an ATM offset pointing mode. This offset capability is one of the major differences between the S-082B instrument and the earlier proposed S-053B instrument. NRL and BBRC have assessed their ability to incorporate the tracking capability in the S-082B instrument and also meet the ML-14A schedule. The following status was reported:

a. It is felt that the primary mirror torque motor can be procured in time to support the schedule.

b. The servo system circuitry design is complete and existing printed circuit board designs currently have this capability built into the system.

c. Impact on the ATM Control and Display Console is expected to be very minor and assurance has been given that space is available for the additional functions.

d. Evaluation of the test program indicates that very minor impact to the test schedule may be required to support additional testing attributable to the servo mirror drive system. It is felt that some overlapping with other testing can be worked.